Violin MEMORY

Technical Report

Best Practices for Connecting Violin Memory Arrays to IBM AIX and PowerVM

Host Attachment Guidelines for Using Violin Memory Arrays with IBM AIX and PowerVM through Fibre Channel Connections

Version 1.1

Abstract

This technical report describes best practices and host attachment procedures for connecting Violin flash Memory Arrays through Fibre Channel to systems running on the IBM AIX operating system with IBM PowerVM virtualization.

Table of Contents

1 Introduction 3
1.1 Intended Audience 3
1.2 Additional Resources 3
2 Planning for AIX Installation 4
2.1 Gateway and Array Firmware 4
2.2 Minimum Recommended Patch levels for AIX 4
2.3 Minimum Recommended Patch Levels for VIO Partition 4
3 Fibre Channel Best Practices 5
3.1 Direct Attach Topology 5
3.2 Fibre Channel SAN Topology 6
3.3 FC SAN Topology with Dual VIO Partitions 6
3.4 SAN Configuration and Zoning 8
4 Virtual IO (VIO Partitions) 9
4.1 Boot Support for Violin LUNS in PowerVM Environment 9
5 Storage Configuration 10
5.1 LUN Creation 10
5.2 Setting NACA Bit per LUN using command-line (vMOS 5.5.1 and below) 12
5.3 Initiator Group Creation 13
5.4 LUN Export to Initiator Group 14
6 LPAR/Host Configuration 15
6.1 Multi-Pathing Driver Considerations 15
6.2 MPIO PCM installation 15
6.3 MPIO Fileset Installation 16
6.4 LUN Discovery 17
7 Discovering LUN and Enclosure Serial no on AIX 18
8 Deploying Multipathing with DMP 19
8.1 Obtaining DMP Binaries 19
8.2 Prerequisites for DMP support on AIX for Violin Storage 19
8.3 AIX Rootability with VERITAS DMP 19
8.4 Installing DMP on AIX 19
About Violin Memory 23

1 Introduction

This technical report describes best practice recommendations and host attachment procedures for connecting Violin arrays through Fibre Channel to systems running on the IBM AIX operating system with IBM PowerVM virtualization. The information in this report is designed to follow the actual process of connecting Violin arrays to AIX systems.

This document covers the information listed below:

- AIX 6.1
- AIX 7.1
- AIX 5.3
- PowerVM Virtualization
- SAN best practices

1.1 Intended Audience

This report is intended for IT architects, storage administrators, systems administrators and other IT operations staff who are involved in planning, configuring and managing IBM P Series environments. The report assumes that readers are familiar with the configuration of the following components:

- vMOS (Violin Memory Operating System) and Violin 3000 and 6000 Series Storage
- IBM P Series Server and AIX operating environments, including PowerVM virtualization
- Fibre Channel Switches and Host bus adapters

1.2 Additional Resources

IBM FAQ on NPIV in PowerVM Environments:
http://www-01.ibm.com/support/docview.wss?uid=isg3T1012037

Symantec Veritas Storage Foundation Installation Guide:
http://www.symantec.com/business/support/resources/sites/BUSINESS/content/live/DOCUMENTATION/5000/DOC5814/en_US/dmp_install_601_aix.pdf

2 Planning for AIX Installation

This section covers AIX platform-specific prerequisites required for a clean and successful install.

2.1 Gateway and Array Firmware

The below are the minimum supported levels for Array and Gateway Code levels for AIX Platform:

Violin Array Model ----------->	**3000**	**6000**
Minimum Recommended Array Code Level	**A5.1.5**	**A5.5.1 HF1***
Minimum Recommended Gateway Code Level	**G5.5.1**	**G5.5.1**
vMOS 6.0 is not yet supported on AIX platform		

HF1* : Hotfix 1

2.2 Minimum Recommended Patch levels for AIX

The below levels of Technology Level (TL) and Service Pack's (SP) are strongly recommended to be upgraded before deploying Violin Storage for use with AIX:

AIX Version	Patch Level (oslevel –s)
6.1	6100-07-05
7.1	7100-01-04
5.3	5300-12-05

2.3 Minimum Recommended Patch Levels for VIO Partition

The below patch level is strongly recommended on the VIO partitions before deploying Violin Storage for use with AIX:

ioslevel	2.1.3.10-FP-23

3 Fibre Channel Best Practices

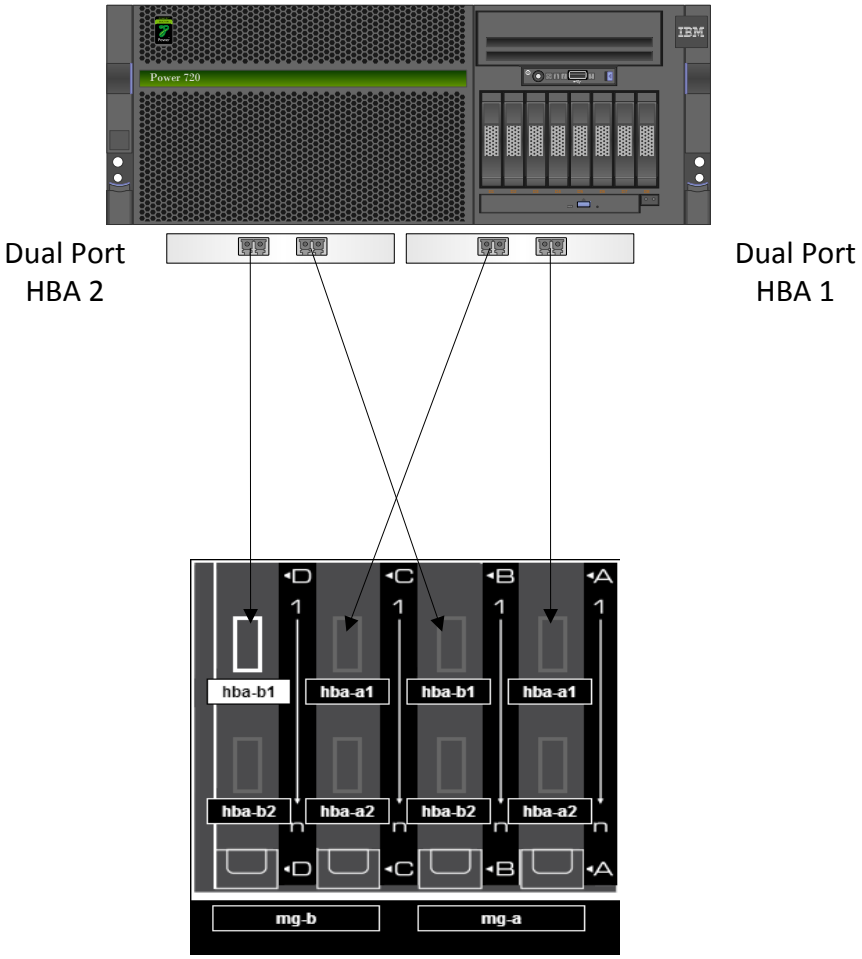
Host attach of Violin Storage to AIX Partitions is supported via the methods listed below:

- Direct Attach
- FC SAN Attach

3.1 Direct Attach Topology

In the topology shown in Figure 1, the host partition's HBAs are directly connected to a Violin target. There is no SAN switch in the topology. To achieve optimal high availability, we need to make sure we attach each HBA to a unique gateway for high availability. This is the simplest host attach and there is no SAN configuration involved as it is directly attached. A total of two hosts can be attached to the Violin Array in this configuration. The below diagram shows one host attached to the array. This topology assumes use of full partitions or fractional partitions without using any virtualization.

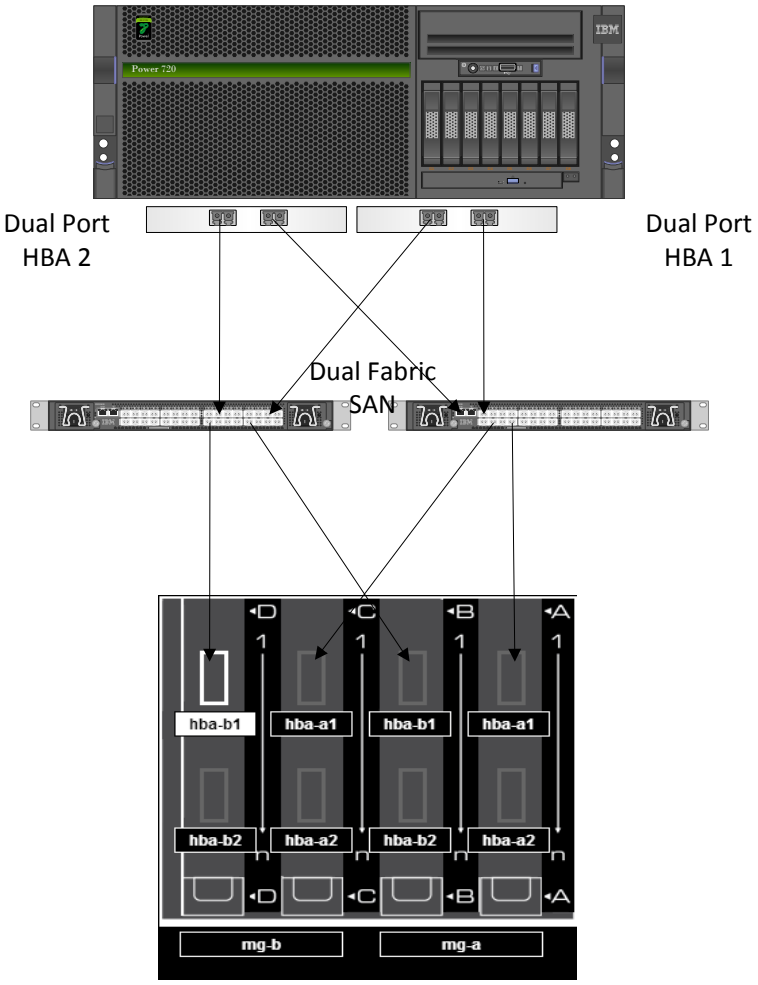
Figure 1. Direct Attach Topology



3.2 Fibre Channel SAN Topology

In the topology shown in Figure 2, the Host Partition's HBAs are directly connected to a Violin Target via a Fiber Channel SAN. To achieve optimal high availability, we need to make sure zone to each HBA port to each gateway (MG) for High Availability. Multiple Hosts can be attached to the Violin Array in this configuration. The below diagram shows one host attached to the fabric. This topology assumes use of full partitions or fractional partitions without using any kind of virtualization.

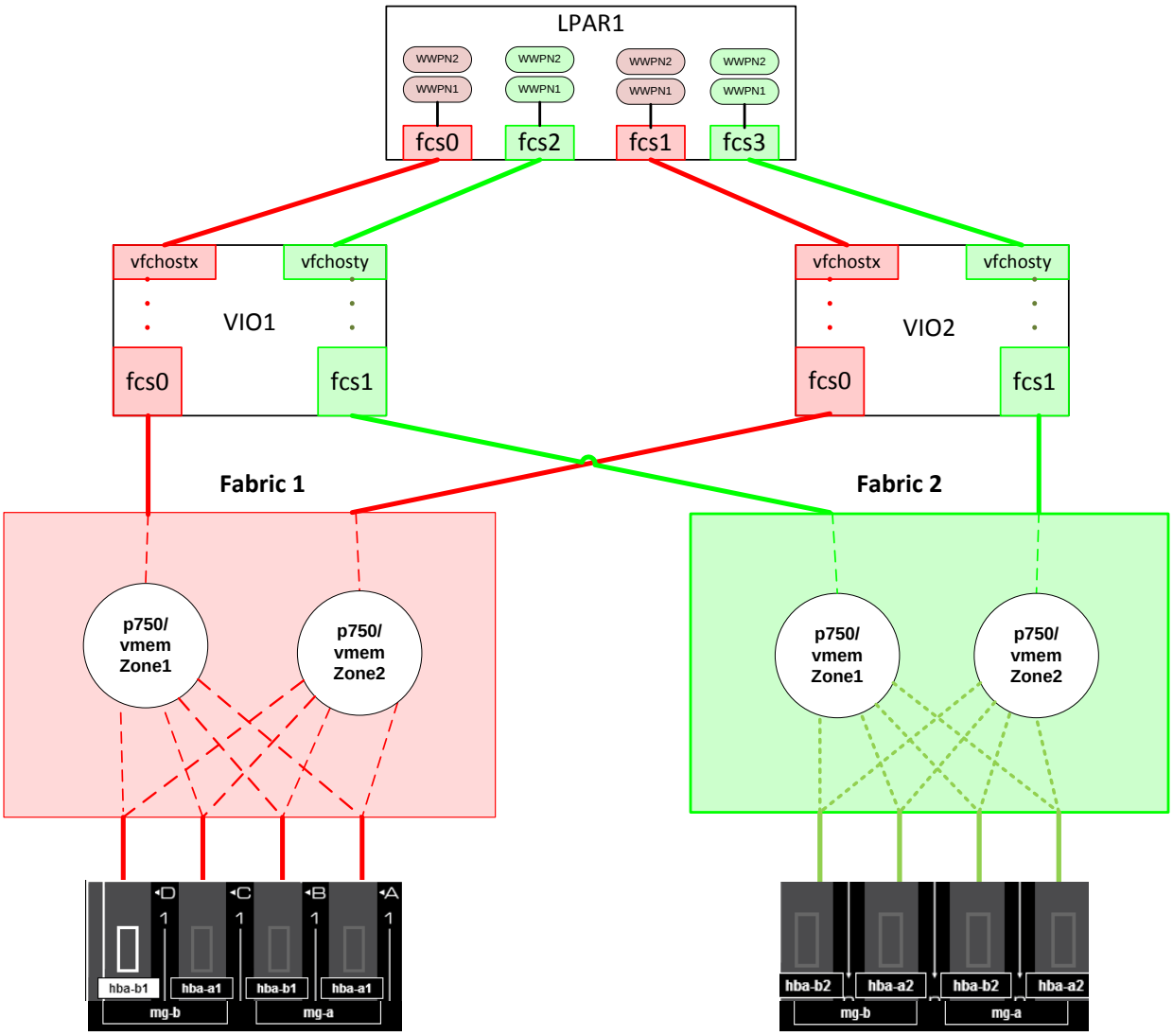
Figure 2. Fibre Channel Topology



3.3 FC SAN Topology with Dual VIO Partitions

The topology shown on the next page shows a LPAR connected via 2 VIO Partitions to Violin Storage.

This is a fully redundant configuration that can survive SAN failures, Gateway (Controller) failures, and HBA failures. The Guest LPAR has 2 Virtual HBAs configured off each VIO Partition. Each VIO partition has two physical HBA ports, each connecting to a unique Fabric that is in turned zoned to both the Gateways.



3.4 SAN Configuration and Zoning

The following best practices are recommended:

- Set the SAN topology to Point-to-Point
- Set the port speed of the Switch port to 8 GB for Violin Targets
- On Brocade 8 GB Switches, please set the fillword setting to 3 for ports connected to Violin Targets.

```
# portcfgfillword <port> 3
```

3.4.1 Zoning Best Practices

- Configure WWPN based zoning or WWPN based Aliases
- Limit HBA ports (Initiators) in a zone to one. For instance, there should not be multiple Initiators in a single zone
- Each HBA port (initiator) can be zoned to multiple Targets (Violin WWPN Ports)
- Limit the number of paths as seen by the host to an allowable number. For example if you have 2 HBA ports out of your server, zone each HBA port to 2 unique target ports on each gateway. I.e. avoid putting all target ports into one zone.
- The ideal number of paths to a MPIO node is 2 or 4 paths. Adding more paths adds more resilience, but does not yield better performance.

4 Virtual IO (VIO Partitions)

IBM PowerVM Supports N Port Virtualization (NPIV) with 8 GB host bus adapters. NPIV allows us to virtualize a port on a Fibre Channel switch. An NPIV-capable FC HBA can have multiple *N_Ports*, each with a unique virtual WWPN. NPIV with the Virtual I/O Server (VIOS) adapter sharing capabilities allow a physical FC HBA to be shared across multiple guest LPARs .The PowerVM implementation of NPIV enables POWER logical partitions (LPARs) to have virtual FC HBAs, each with a unique worldwide port name (WWPN). Each virtual Fibre Channel HBA has a unique SAN identity similar to that of a dedicated physical HBA.
It should be noted that NPIV attribute is enabled on the Switch port connected to VIO Partition on the host side and not on the ports connected to Violin Targets.

4.1 Boot Support for Violin LUNS in PowerVM Environment

Logical partitions that connect to a VIO Partition do not have physical boot disks. Instead, they boot directly off a Violin LUN, which needs to be mapped during LPAR configuration.
Both vSCSI and NPIV LUNS are supported for boot support.

- It is recommended to create a separate “initiator group” for boot devices when configuring Storage.
- It is required to install the Violin MPIO Driver in the VIO Partition if configuring vSCSI LUNS (for boot).The MPIO driver ensures that there is proper multi-path support for boot devices.
- If you have a NPIV only configuration then it is not required to install the driver in the VIO partition.
- If you do need to install the Violin MPIO Driver in a VIO Partition, then please ensure that the Partition sees only “one and only” path for during driver install. IF the Driver detects multiple paths, the install will fail. After the driver installation is complete, one can enabled multiple paths for boot LUNS
- There are a few HBA parameters required to be set for optimal operation. These parameters are covered in later sections of this report.
- If you are planning to upgrade AIX version on a partition when it is booting off a Violin LUN which uses NPIV, please follow the following steps to ensure a smooth upgrade: (Below steps are not required for vSCSI boot)
    1. Stop application, umount file-systems, vary off volume groups.
    2. Uninstall the AIX Multipath driver package for Violin
    3. Disconnect all but one SAN path to the Partition
    4. Reboot the Partition – it will still boot from the SAN with single path into AIX
    5. Upgrade to newer AIX version and apply patches.
    6. Then install the Violin MPIO driver package for appropriate version for AIX
    7. Reboot the Partition and verify that multiple paths are discovered by MPIO for boot and data LUNS.

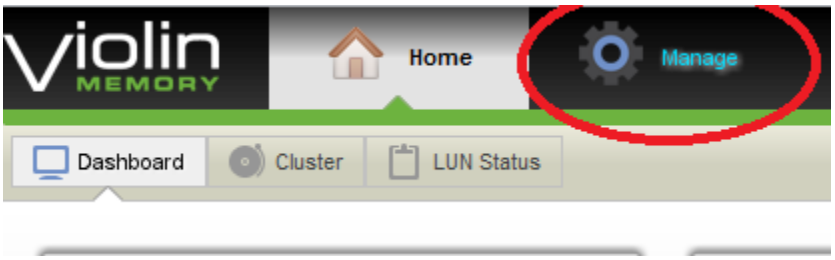
5 Storage Configuration

NOTE: This LUN configuration is identical for MPIO and DMP.

5.1 LUN Creation

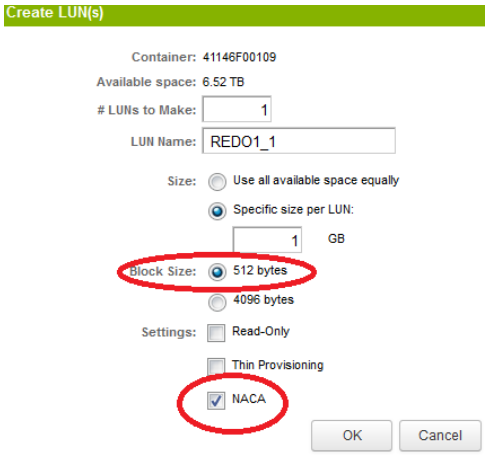
1. **Log into the Array** GUI IP/hostname of the Gateway and login as admin

2. **Click on "Manage"** and this will drop you directly into LUN management Screen.



3. **Create new LUNS**: Click on the + sign to create new LUNS in the container. This opens up a dialog box to create new LUNS.

4. **Select no of LUNs**, unique names for LUNS, size for LUNS in Gigabytes, block size=512 bytes (4 K Block size is not supported on AIX), select NACA (vMOS 5.5.2 and higher). Note: Thin Provisioning is not supported with vMOS 5.x.

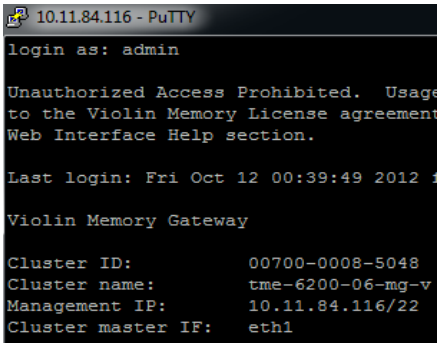


5.2 Setting NACA Bit per LUN using command-line (vMOS 5.5.1 and below)

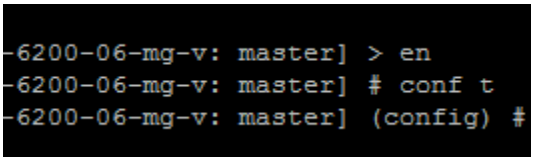
1. **Setting NACA bit for AIX LUNS:**

   vMOS 5.5.1 does not expose NACA bit from the GUI and has to be set from the command-line.

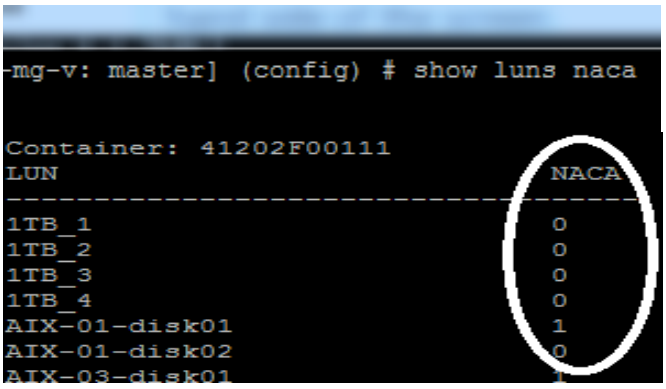
   Login to the Cluster IP address of the Gateway using PUTTY(ssh) and username=admin.



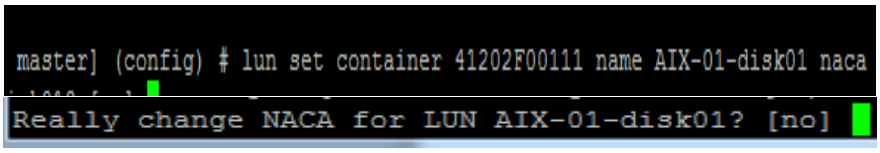
2. **Change mode to privileged user**



3. **Display LUNS for NACA Bit** (this displays all the LUNS on the array). NACA bit should be 1 for all AIX LUNS.



4. **Set the NACA bit for the AIX LUNS**. The syntax is (hit tab) lun set container <tab> name <tab> LUN-name naca.



5. **Change NACA bit for all the LUNS** you plan to export on AIX Hosts and check that it is successful on the LUNS that you want.

```
Container: 41202F00111
LUN                                 NACA
-----------------------------------------
1TB_1                               1
1TB_2                               1
1TB_3                               1
1TB_4                               1
AIX-01-disk01                       1
```

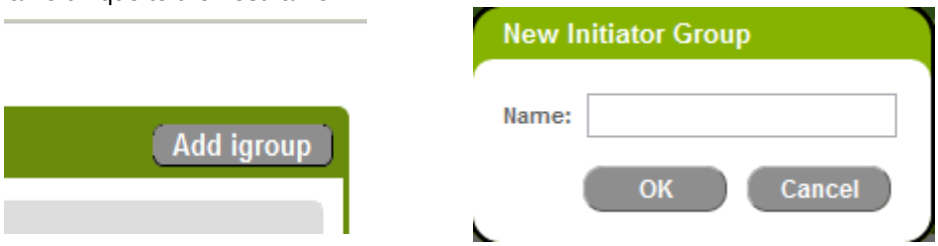
6. **Save the NACA bit settings**

   # write mem

5.3 Initiator Group Creation

Note: If setting up a VIO environment, it is recommended to set up separate Initiator Groups for LPAR boot LUNS (one per LPAR) and data LUNS (one per cluster).

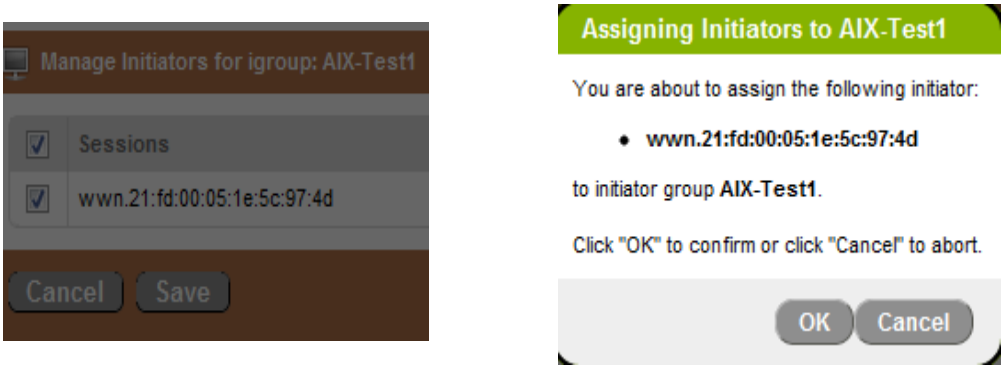
1. **Create IGROUP.** Create (Add) a new Initiator group (IGroup) by clicking on “add IGroup”, provide a name unique to the hostname.



2. **Ensure that the Zoning is done** and the HBA’s can see the Array Targets based on the topology decided.

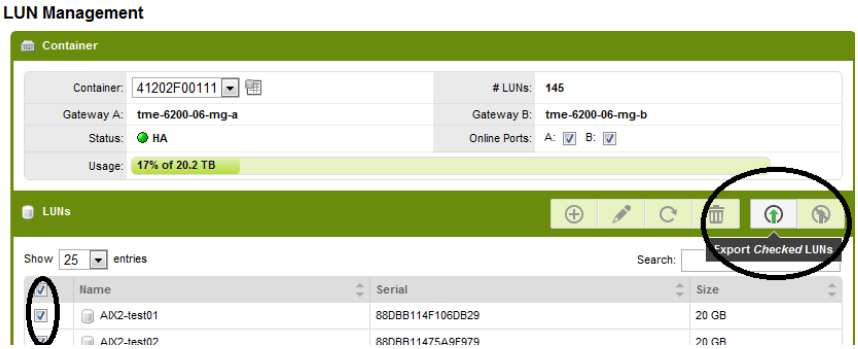
   Then **Select the right HBA WWPNs** you want to be associated with the iGroup and hit “save.”

   Then **assign initiators** to Igroup and click OK.

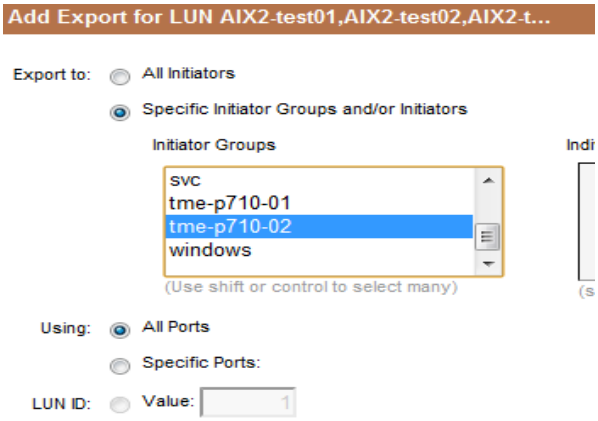


5.4 LUN Export to Initiator Group

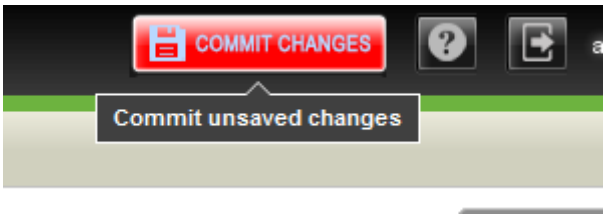
1. **Export LUNS to the IGroup** by selecting them from the checkboxes and click on “export Checked LUNS.”



2. **Select your initiator group** and click “OK.”



3. **Save your configuration** by committing changes by clicking on COMMIT CHANGES at the top right hand side of the screen.



6 LPAR/Host Configuration

Please follow the steps provide in this section for LPAR/host configuration.

6.1 Multi-Pathing Driver Considerations

Violin supports two multi-path options on AIX:

- IBM MPIO
- Symantec VERITAS DMP

NOTE : MPIO and DMP can coexist with EMC Powerpath on AIX

Violin 3000 and 6000 Arrays are supported with IBM MPIO on AIX. Violin distributes a path control module (PCM) that supports IBM MPIO as an Active/Active Target. The PCM must be installed on the LPAR to support multipathing using MPIO.
Violin arrays are also supported and certified with Symantec Veritas DMP and Storage Foundation 6.0.1. The array support library for Violin is available for download from Symantec.

6.2 MPIO PCM installation

As a prerequisite to installing the PCM, it is required to set these parameters in both the guest LPAR and VIO partitions.

6.2.1 Setting HBA Parameters

It is **required** to set the following attributes as follows on each of the FC protocol devices connecting to a Violin Target depending on the MG BIOS. Please contact Violin Memory Technical Support to determine if the BIOS version on the MG supports AIX default HBA settings. Determining the BIOS version of the MG requires a "restricted shell license" to be installed on the MG which is not available to customers.

MG BIOS version	Dynamic tracking	fc_error_recov
VMCYL010	yes (AIX default)	fast_fail (AIX default)
Lower than VMCYL010	no	delayed_fail

If required to change these values, the command examples are provided below.

Making these values effective requires a reboot of the partition.

- Dynamic tracking for FC devices
  # chdev -l fscsi0 -a dyntrk=no –P

- FC Error Recovery
  # chdev -l fscsi0 -a fc_err_recov=delayed_fail –P

It is recommended to set the following attributes as follows on each of the FC Adapter connecting to a Violin Target to ensure that the FC layer yields maximum performance.

- hba_num_commands
  # chdev -l fcs0 -a num_cmd_elems=2048 -P

- Max Transfer Size
  # chdev -l fcs0 -a max_xfer_size=0x200000 -P

NOTE: It is required to reboot the LPAR to make the above settings effective.

6.3 MPIO Fileset Installation

Download the Violin MPIO filesets from http://violin-memory.com/support after logging in with you user id.

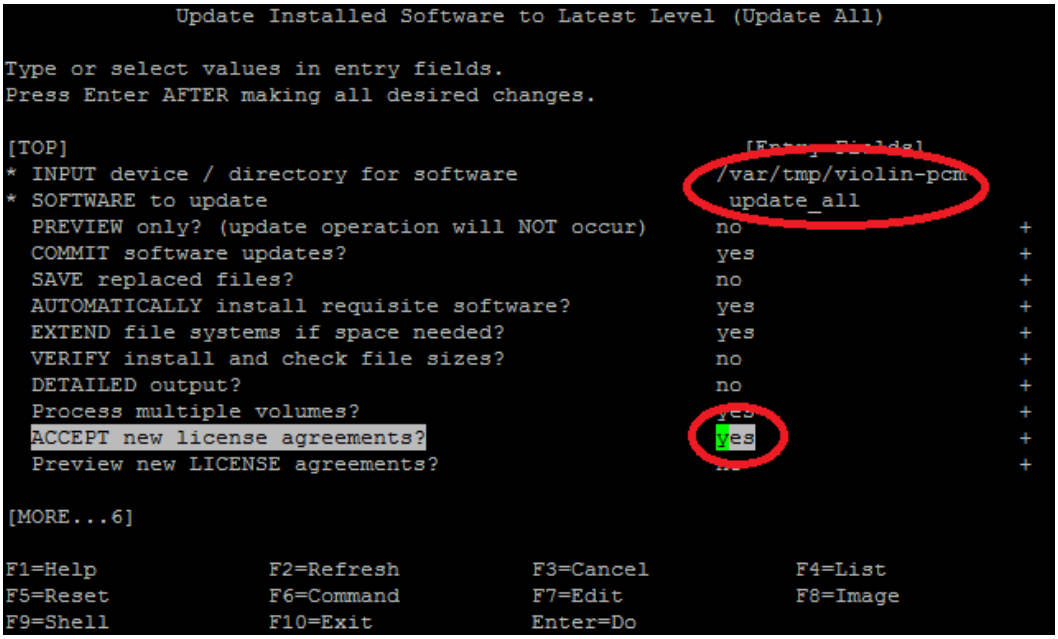
Depending on the version of AIX you are using, you need to install the appropriate library.

AIX 7.1	7.1.0.3devices.fcp.disk.vmem
AIX 6.1	6.1.0.3devices.fcp.disk.vmem
AIX 5.3	5.3.0.3devices.fcp.disk.vmem

6.3.1 Installing the PCM

1. **Copy** the library into a folder /var/tmp/violin-pcm and verify the mdchecksum from the download site.
2. **Run** the AIX installer to install the library.

   # smitty install (pick the input device/directory as /var/tmp/violin-pcm)



3. **Verify** that the PCM is correctly installed by the below command. (An example for AIX 6.1 is shown)

```
# lslpp -l devices.fcp.disk.vmem.rte
  Fileset                      Level  State      Description
  ----------------------------------------------------------------------------
Path: /usr/lib/objrepos
  devices.fcp.disk.vmem.rte  6.1.0.3  COMMITTED  Violin memory array disk support for AIX 6.1
release
```

6.4 LUN Discovery

After creating LUNS and exporting them to the appropriate Initiator groups, you can discover LUNS inside the guest LPAR using cfgmgr.

cfgmgr

1. To identify what LUNS have been discovered,

lsdev –Cc disk (partial listing)

hdisk2 Available 04-00-01 VIOLIN Fibre Channel controller port
hdisk3 Available 04-00-01 MPIO VIOLIN Fibre Channel disk
hdisk4 Available 04-00-01 MPIO VIOLIN Fibre Channel disk
hdisk5 Available 04-00-01 MPIO VIOLIN Fibre Channel disk

NOTE : VIOLIN Fibre Channel Controller port is the SES device and not a usable LUN

2. To identify multiple paths detected for MPIO devices (an example)

lspath -l hdisk2 -F"name,parent,connwhere,path_id,status"

hdisk2,fscsi0,21000024ff35b6e2,1000000000000,0,Enabled
hdisk2,fscsi0,21000024ff3854e8,1000000000000,1,Enabled
hdisk2,fscsi2,21000024ff35b622,1000000000000,2, Enabled
hdisk2,fscsi2,21000024ff35b690,1000000000000,3, Enabled

In the above example , hdisk2 is a MPIO node which detects 4 logical paths via 2 HBA ports.

The violin PCM sets highlighted attributes on VIOLIN MPIO devices as shown below

lsattr -El hdisk2 (partial listing)

PCM	**PCM/friend/vmem_pcm**	**Path Control Module**	True
PR_key_value	none	Persistante reservation value	True
algorithm	**round_robin**	**Algorithm**	True
q_type	simple	Queuing TYPE	False
queue_depth	**255**	**Queue DEPTH**	True
reassign_to	120	REASSIGN unit time out value	True
reserve_policy	no_reserve	Reserve Policy	True
rw_timeout	30	READ/WRITE time out value	True
scsi_id	0x11300	SCSI ID	True
start_timeout	180	START unit time out value	True
timeout_policy	retry_path	Timeout Policy	True
unique_id	2A1088DBB1141F91FF2009SAN ARRAY06VIOLINfcp	Unique device identifier	False
ww_name	0x21000024ff3854e8	FC World Wide Name	False

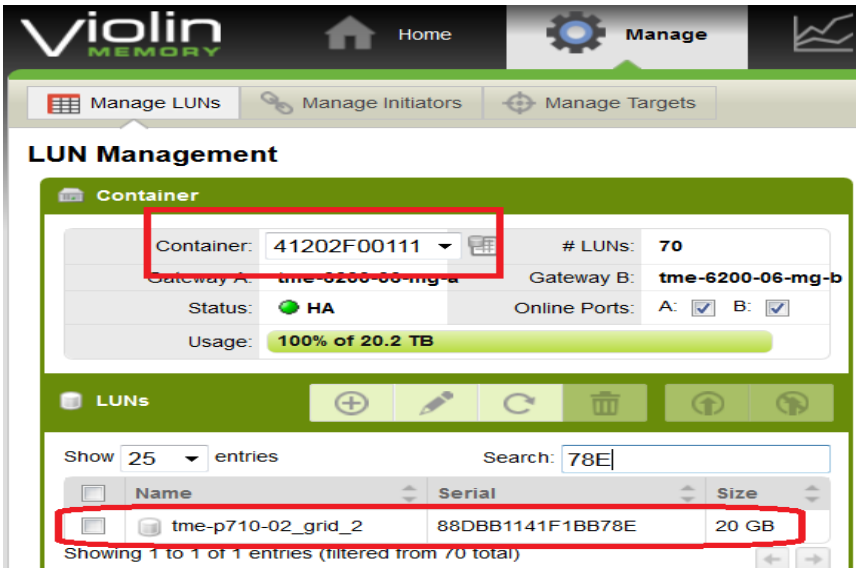
7 Discovering LUN and Enclosure Serial no on AIX

The vMOS code level , LUN serial no and Array/Enclosure Serial no can be determined by the following command as shown below:

```
# lscfg -vpl hdisk29
 hdisk29          U78AB.001.WZSHR28-P1-C2-T1-W21000024FF35B691-LB000000000000
                                          MPIO VIOLIN Fibre Channel disk

 Manufacturer.....VIOLIN
 Machine Type and Model......SAN ARRAY
 EC Level.....551                          <=  vMOS level
Device Specific.(Z0).....000006323F081002
Device Specific.(Z1).....41202F00111       <= Container Serial No
Device Specific.(Z2).....tme-p710-02_grid_2
Device Specific.(Z3).....88DBB1141F1BB78E   <=  LUN Serial No
```

The following screenshot highlights the Container Sr no and LUN Sr no for a LUN:



At this point, the LUNS are ready to be deployed into control of a Volume Manager. It is recommended to reboot the LPAR at this stage as the NACA bit setting, HBA parameters changed will be effective only after a LPAR reboot. If setting these parameters inside the VIO Partitions, it is recommended that the VIO partitions be rebooted as well before rebooting the guest LPARs.

8 Deploying Multipathing with DMP

If you need more information about SYMANTEC Storage Foundatio, visit: http://www.symantec.com/storage-foundation

8.1 Obtaining DMP Binaries

Storage Foundation can be downloaded from Symantec web site:

https://www4.symantec.com/Vrt/offer?a_id=24928

The Array Support Library support package for Violin is available from Symantec as well:

https://sort.symantec.com/asl

Storage Foundation documentation from Symantec can be found here:
https://sort.symantec.com/documents

This document will refer to DMP documentation whenever required.

8.2 Prerequisites for DMP support on AIX for Violin Storage

To determine AIX prerequisites for Storage Foundation, please run the installer with the pre-check option after downloading DMP media from the correct directory.

```
# installer –precheck.
```

This option will determine the correct TL level and APAR for AIX, disk space requirements for Storage Foundation etc. Please upgrade your server patch level appropriately and increase disk-space if determined by the installer before installing DMP.

8.3 AIX Rootability with VERITAS DMP

VERITAS Storage Foundation supports the root/boot disk being under DMP multi-pathing control i.e. server booting from a SAN LUN rather than a local boot disk. Rootability is an option, meaning that it is not mandatory for boot disk to be managed by DMP. Rootability is not covered in detail in this document. Please refer to DMP documentation if you need more details.

8.4 Installing DMP on AIX

This section provides a short description of the procedures for installing Storage Foundation on an AIX Server where Violin Storage will be deployed. For detailed procedures, read Chapter 6 the Veritas Storage Foundation Install guide available on http://sort.symantec.com.

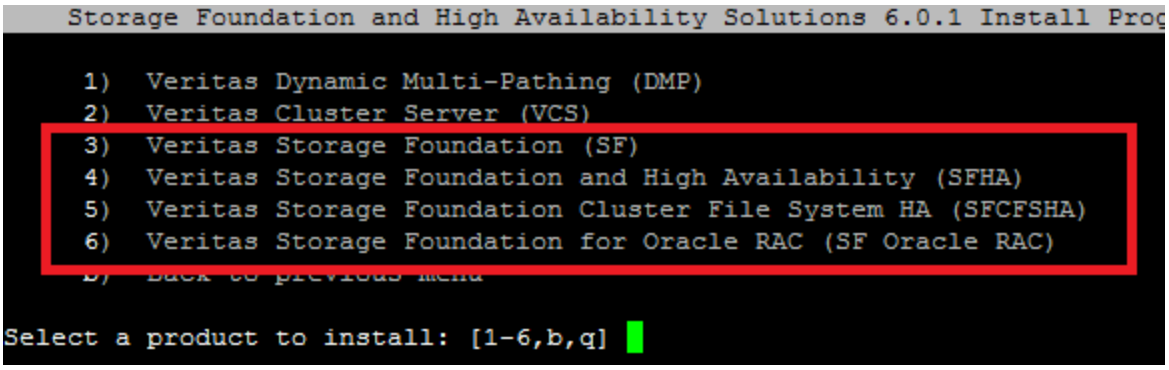
8.4.1 Running the Installer

1. Run the installer and select Dynamic Multi-Pathing as your choice to install.

   # cd …./../.dvd1-aix (the folder for DVD1)

   # ./installer (Please run this as a “root” user)

2. Select Option I - install a product.


Storage Foundation and High Availability Solutions 6.0.1 Install Prog
1) Veritas Dynamic Multi-Pathing (DMP)
2) Veritas Cluster Server (VCS)
3) Veritas Storage Foundation (SF)
4) Veritas Storage Foundation and High Availability (SFHA)
5) Veritas Storage Foundation Cluster File System HA (SFCFSHA)
6) Veritas Storage Foundation for Oracle RAC (SF Oracle RAC)
Select a product to install: [1-6,b,q]

3. Please select Option 3 ,4, or 5 depending on which stack you want to install and follow the steps as instructed by the installer.
4. Reboot the host if required (prompted by the installer).
5. Run an installer post-check.

   # ./installer –postcheck `uname-n`

8.4.2 Array Support Library for DMP

1. Install Array Support Library (ASL) package for Violin Storage Arrays.
2. Download the latest AIX package from https://sort.symantec.com/asl/latest.
3. Install the ASL package. as a “root” user.

   # installp -acgX -d VRTSaslapm.bff VRTSaslapm

8.4.3 DMP Patch for bos-boot Issue

There is a known issue with AIX with DMP which has been fixed in a point patch. This patch is mandatory before deploying DMP as it can cause the system to hang during reboot intermittently if not deployed. We still recommend that this patch be installed as it has multiple stability fixes.

This patch is available on this link and should be applied before proceeding further. The patch install instructions are in the link.

8.4.4 Discovering LUNs Under DMP Control

Run a DMP device scan.

vxdisk scandisks

Verify that DMP recognizes the 1st Violin Enclosure as vmem0.

```
 # vxdmpadm listenclosure all
ENCLR_NAME      ENCLR_TYPE    ENCLR_SNO     STATUS      ARRAY_TYPE    LUN_COUNT
==========================================================================
vmem0           VMEM          41202F00111   CONNECTED   A/A           16
disk            Disk          DISKS         CONNECTED   Disk          2
```

If the Array is not recognized as a VMEM enclosure this means that the Array Support library for Violin Storage is not installed on the server. This can be verified by running the below command. If this command returns null, then please check if ASL update package is installed for Violin Arrays and contact Symantec Support if required.

```
# vxddladm listsupport | grep -i violin
libvxviolin.so      VIOLIN          SAN ARRAY
```

One can verify multi-pathing at a DMP level by picking a LUN as discovered by DMP and listing the sub-paths of a DMP node.

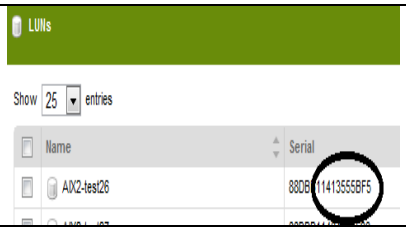
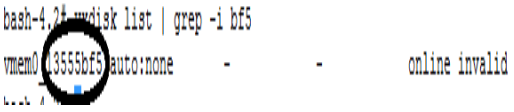
```
bash-4.2# vxdisk list  ( partial listing)
DEVICE                  TYPE          DISK    GROUP      STATUS
disk_0                  auto:LVM      -       -          LVM (internal disk LVM Control)
disk_1                  auto:LVM      -       -          LVM (internal disk LVM Control)
vmem0_a1d78869          auto          -       -          online-invalid ( new LUN)
vmem0_b38211bb          auto          -       -          online-invalid
vmem0_dc014194          auto          -       -          online-invalid
vmem0_d564b754 auto     -             -       LVM
```

We pick the LUN vmem0_a1d78869 and seek its DMP subpaths.

```
# vxdmpadm getsubpaths dmpnodename=vmem0_a1d78869
NAME    STATE[A]   PATH-TYPE[M] CTLR-NAME  ENCLR-TYPE   ENCLR-NAME    ATTRS
================================================================================
hdisk136    ENABLED    -            fscsi0     VMEM          vmem0          -
hdisk229    ENABLED    -            fscsi2     VMEM          vmem0          -
hdisk322    ENABLED    -            fscsi2     VMEM          vmem0          -
hdisk415    ENABLED    -            fscsi0     VMEM          vmem0          -
```

8.4.5 Correlating LUNS in DMP Command-line vs. Violin Array Management GUI

The steps listed below provide an easy way to correlate LUNS from DMP Command-line v/s Array Management GUI:

In the Violin GUI, the suffix of a LUN Sr no can be correlated with the Array Volume ID(AVID) as discovered by DMP	
The suffix of the Sr. no of Exported LUNs will show as the suffix of a Disk access (DA) name in DMP Command-line. e.g. #vxdisk list | grep -i < suffix of sr no >	

8.4.6 Setting Queue Depth for AIX LUNs Discovered

At this time, Violin does not ship ODM predefines for the Violin Array for DMP. As a result, LUN queue depth needs to be set for each of the LUNs discovered by Violin Array. Violin provides a script for this purpose. Please copy and paste this into a shell script and execute it.

```
echo " checking for a Violin Enclosure managed by DMP"
ENCL=`vxdmpadm listenclosure all | grep -i vmem | awk '{print $2}'`
if test "$ENCL" = "VMEM"
   then
 echo ""
 echo "Optimizing queue depth settings for discovered Violin LUNs"
 echo ""
 for disk in `vxdisk path | grep -i vmem |  awk '{print $1}' 2>/dev/null`
  do
       chdev -l $disk        \
          -a clr_q=no        \
          -a q_err=no         \
          -a q_type=simple     \
          -a queue_depth=255   -P
echo "set queue depth to 255 for" $disk
 done
else
 echo "VIOLIN DMP enclosure is not detected please install the Array Support
for Violin Arays"
fi
```

About Violin Memory

Violin Memory is pioneering a new class of high-performance flash-based storage systems that are designed to bring storage performance in-line with high-speed applications, servers and networks. Violin Flash Memory Arrays are specifically designed at each level of the system architecture starting with memory and optimized through the array to leverage the inherent capabilities of flash memory and meet the sustained high-performance requirements of business critical applications, virtualized environments and Big Data solutions in enterprise data centers. Specifically designed for sustained performance with high reliability, Violin's Flash Memory Arrays can scale to petabytes and millions of IOPS with low, predictable latency. Founded in 2005, Violin Memory is headquartered in Mountain View, California. For more information about Violin Memory products, visit www.vmem.com.

Violin Memory, Inc.
685 Clyde Ave, Mountain View, CA 94043
Ph: 1-888-9VIOLIN (984-6546)
E-mail: sales@vmem.com